Multi-layer web formation section

The invention relates to a method according to the preamble to Claim 1.

In addition, the invention relates to a formation section according to the preamble to Claim 17.

In the formation section according to the invention, a multi-layer web is made in at least two successive wire units having one common web. The first partial web is formed in a first wire unit, which may be a single-wire or a two-wire unit. After the first wire unit the first partial web is guided into the second wire unit, which is equipped with a two-wire section and wherein a new pulp layer is supplied by a headbox atop the first partial web at the beginning of the two-wire section of the second wire unit. The second wire unit may be followed by a third wire unit, a fourth wire unit etc., and in each one a new pulp layer is supplied by a headbox atop the preceding layers at the beginning of the two-wire section of the concerned wire unit.

When a web is made of aqueous wood-fibre stock, water is removed from the pulp on the formation section through the formation wire or formation wires in order to start the web formation. The wood pulp fibres remain randomly distributed on the formation wire or in between the formation wires, which are travelling together.

Fibre pulps of different types are used depending on the quality of web to be made. The water quantity, which can be removed from different fibre pulps in order to achieve a web of good quality, is a function of many factors, such as, for example, a function of the desired basis weight of the web, the designed velocity

of the machine, and the desired level of fines, fibres and fillers in the final product.

Equipment of several types are known in the web formation section, that is, in the former, such as foil lists, suction boxes, hitch rolls, suction rolls and rolls provided with an open surface, which have been used in several different formations and orders in an attempt to optimise the quantity of removed water, the time and location in the formation of the web. Making a web is still an art in part and science in part in that simply removing water as quickly as possible will not produce a final product of optimum quality. In other words, making a final product of a high quality especially at high velocities is a function of the dewatering quantity, the dewatering method, the time of dewatering and the location of dewatering.

When it is desirable to maintain or improve the quality of the final product when proceeding to higher production speeds, unforeseeable problems often occur, in consequence of which either the production quantity must be reduced to maintain the desired quality or the desired quantity must be given up in order to achieve a higher production quantity.

It is known in the state of the art to use formation shoes to guide one or two formation wires on the formation section. It is also known to use a so-called formation roll provided with an open surface, for example, a perforated one, to receive water into the formation roll from the fibre pulp lying on the formation wire.

The state-of-the-art list elements or foils of formation shoes or list shoes, which have a curved surface or which are planar, are arranged in the cross machine direction at right angles to the travelling direction of the formation wire. In between the list elements there are gaps defining leading edges for the list elements. A stock jet is directed against the formation wire over the leading edge of the formation shoe/list in such a way that part of the water contained in the stock jet will travel through the formation wire to end up below the shoe/list. Each foil, list

element or formation shoe is either open at its bottom to the pressure of the air outside or they are connected to a vacuum source in order to improve the dewatering process by forcing water into the gaps in between the foils or list elements. The list elements constitute the cap of the foil or formation shoe.

When increasing machine velocities, new phenomena will occur in the web formation and they will affect the machine runnability and the looks of the produced final product as well as its internal structure. An undesirable distribution of fines and fillers may occur in the surface or internal parts of the final product, whereby retention will suffer.

Two-wire formers used in board-making machines and in papermaking machines can be divided into two main types, which are the roll jaw former and the list jaw former.

The roll jaw former, wherein the pulp jet of the headbox hits a roll having a relatively large radius, is insensitive to minor geometric errors, to errors in the jet quality and to external effects, such as air resistance and water drops. As regards characteristics in the Z direction, such as the distribution of fillers and anisotropy of fibres, an excellent two-sidedness is achieved. This is so because the fibre mat is at first formed at the same time on both wires at a constant dewatering pressure (that is, non-pulsatingly). A good retention is also achieved thanks to the constant dewatering pressure in the initial part of the dewatering zone.

A drawback of the roll jaw former is that the rotation of the formation roll brings about an under-pressure pulse on the discharge side of the roll nip. This under-pressure pulse partly damages (crushes) the structure of the formed web as it is travelling from the formation roll's dewatering zone where a constant pressure exists to the following dewatering zone where a pulsating pressure exists, if the web is too wet at this point. Hereby the damaged web can no longer withstand powerful pulsating, whereby the dewatering must be limited in the pulsating de-

watering zone. The price of the formation roll and its spare parts as well as the need for roll service and the resulting time of machine standstill also constitute a disadvantage. In addition, it has been found to be a problem with the roll jaw former that the dewatering capacity is not sufficient at high velocities and with dense pulps. In addition, the big rotating roll forms a source of vibrations in the formation section. In practice, the radius of the formation roll cannot be very long, whereby the wires travelling over it are subjected to a great force directed towards the shell. For this reason, the outer wire tends to attach at its edges to the inner wire, whereby the pulp located in between the wires is subjected, especially when the headbox jet is very thick, to a flow motion directed towards the centre, in consequence of which the orientation of fibres becomes less advantageous. The big formation roll also takes much space and, in addition, a standby roll is also needed at all times.

In a list jaw former, the pulp jet of the headbox hits a shoe having a relatively long radius and where pulsating dewatering is pursued. Due to the pulsating dewatering right at the beginning of the formation section, the former has a good formation potential. Since all dewatering components are fixed, acquisition and service costs are lower than when using a roll as the first dewatering device.

However, the list jaw former is sensitive to many errors, such as changes occurring in the pulp jet, and this circumstance restricts the former's efficient operation. The dewatering is quite asymmetric to begin with, which in the Z direction results in unequal sidedness in the web structure, especially as regards the distribution of fillers and the anisotropy of fibre orientation. Since the dewatering of pulp is done under a pulsating pressure to begin with, retention is low.

The roll jaw former and the list jaw former may also be combined to form a roll-list jaw former. A non-pulsating dewatering zone together with a pulsating dewatering zone are used as a combination in the roll-list jaw former. The former's first non-pulsating dewatering zone comprises a formation roll (a suction roll provided

with an open surface), after which a pulsating dewatering zone is arranged, wherein a loading element-suction box combination is located. With such an arrangement a good retention and a symmetric paper have been achieved, but poorer formation results than with the traditional list jaw formers. This is due to the fact that the rotational motion of the formation roll brings about an under-pressure peak in the web after the formation roll, which will damage the web already formed.

The big rotating roll of the roll-list jaw former forms a vibration source in the formation section. In practice, the radius of the formation roll cannot be very long, whereby the wires travelling over it are subjected to a strong force directed towards the shell. For this reason, the outer wire tends to attach at its edges to the inner wire, whereby the pulp located in between the wires is subjected, especially with very thick headbox jets, to a flow motion directed towards the centre, in consequence of which the fibre orientation becomes less advantageous. A big formation roll also takes much space and, in addition, a standby roll is also required at all times.

US Patent 5,427,654 presents a multi-layer web formation section having two successive wire units. The first wire unit is a fourdrinier wire unit, wherein the bottom layer is formed on a fourdrinier wire loop, and the second wire unit is a two-wire unit, which is formed by the fourdrinier wire of a fourdrinier wire unit and by a separate top wire. At its lower surface the fourdrinier wire is supported by an adjustable shoe with a curved surface before the two-wire stretch. This adjustable shoe can be used to adjust the angle, at which the fourdrinier wire enters the two-wire stretch. A secondary headbox supplies a pulp suspension jet on to the bottom layer into a jaw formed at the beginning of the two-wire stretch. The two-wire stretch has two successive pulsating dewatering zones.

In US Patent 5,427,654, a first pulsating dewatering zone is located at the beginning of the two-wire stretch. This first pulsating dewatering zone comprises a

curved dewatering shoe under the fourdrinier wire, with which a part of the water of the surface layer is removed by the tension of the wires to the outside by way of the top surface of the surface web. At the beginning of the two-wire stretch before the curved dewatering shoe and above the top wire an under-pressure box is located, which is divided into chambers and which is used for collecting the water discharging through the top surface of the surface layer. Under the fourdrinier wire at the under-pressure box dewatering foils are also located to boost the dewatering from the web. In addition, the curved dewatering shoe is provided with lists in the cross machine direction and with an under-pressure affecting in between the lists. In a solution of this kind, the thickness of the lip jet of the secondary headbox must not exceed an approximate value of 10 mm, because the pulsating dewatering will otherwise cause too high pressure peaks in the web.

In US Patent 5,427,654, the pulsating dewatering zone at the beginning of the two-wire stretch is followed by a second pulsating dewatering zone. This second pulsating dewatering zone comprises after the curved dewatering shoe of the first dewatering zone a reversed suction box located above the top wire and provided with a curved surface. In the curved surface of the reversed suction box there are lists in the cross machine direction, and an under-pressure affects in the gaps between the lists. Below the fourdrinier wire at the suction box dewatering foils are arranged at the gaps between the lists of the suction box.

The solution according to the invention constitutes an improvement on the state-of-the-art solutions.

The main characterising features of the method according to the invention are presented in the characterising part of Claim 1.

The main characterising features of the formation section according to the invention are presented in the characterising part of Claim 17.

Other characterising features of the invention are presented in the dependent claims.

In the formation section according to the invention there are at least two successive wire units, which have one common web. The first wire unit is either a single-wire or a two-wire unit, to which a stock jet is supplied by a first headbox in order to form a first partial web. The second wire unit is a two-wire unit, and in the jaw of the forward end of its two-wire stretch a new pulp layer is supplied by a second headbox on to the first partial web. The dewatering of this two-wire stretch of the second wire unit is both structurally and process-technically a combination of two elements in such a way that all the advantages of a list jaw former and a roll jaw former can be achieved without their associated drawbacks.

The first element is a fixed formation shoe having a curved cap and provided with openings extending through the cap, in which formation shoe it is possible to use under-pressure to control and boost the dewatering. The formation shoe is constructed in such a way that dewatering may take place freely at the same time through both formation wires travelling over the curved cap of the formation shoe. The cap of the formation shoe provides an essentially constant dewatering pressure according to equation $P = T/R$, wherein P = pressure of the liquid in between the formation wires travelling over the formation shoe, T = tension of the outermost web, and R = radius of curvature of the fixed formation shoe. The intention is that the formation shoe will not cause any pulsating dewatering even when the dewatering is boosted by under-pressure. The formation shoe can be thought as being the curve of a "fixed roll" provided with an open surface. The cap has a large open surface area and through openings it is connected to an under-pressure chamber located inside the formation shoe. The openings in the cap of the formation shoe are formed in such a way that pulsating dewatering is avoided, which would result if the openings were formed by longitudinal gaps in the cross machine direction. In order to bring about this essentially constant pressure, these openings are either holes, gaps arranged essentially in the machine direction,

wave-like gaps, upstanding contact surfaces in the machine direction to carry the web above the shoe cap, etc. The cross-section of the holes may be round, square, elliptic or polygonal.

The second dewatering element is a pulsating dewatering element comprising fixed dewatering lists mounted on the other side of the formation wires in the cross machine direction and provided with gaps. In connection with the fixed lists it is possible to use under-pressure, which through the gaps in between the lists affects the pulp located in between the formation wires. In addition, in the gaps between the fixed dewatering lists it is possible to locate adjustable dewatering lists on the side opposite to the formation wires in relation to the fixed dewatering lists. These adjustable dewatering lists are used to boost further the pulsating impact on the web.

Dewatering first takes place in the non-pulsating dewatering zone essentially under a constant pressure as two-sided dewatering, owing to which the web structure is symmetric in the Z direction.

No under-pressure peak occurs on the output side of the non-pulsating dewatering zone, because the structure is fixed. In this way that tendency damaging the web is avoided, which relates to the non-pulsating dewatering zone formed by a roll.

In the non-pulsating dewatering zone water can be removed even from a very wet web without breaking the structure of the web. In consequence of this, the web may be brought very wet to the formation shoe, where water is removed from the web through the openings of the non-pulsating formation shoe under the effect of under-pressure existing in the openings. A very effective dewatering is provided in this manner. After the non-pulsating dewatering zone the web is guided into the pulsating dewatering zone with such a dry-matter content that formation of the web can be improved by pulsating dewatering. The higher dewatering capacity also allows a higher production rate.

The capital and maintenance costs of a non-pulsating fixed formation shoe are lower than those of a roll and standby roll.

According to each purpose of use, the radius of the non-pulsating fixed formation shoe and the shoe length in the machine direction can be changed within a larger range than would be practical when using a roll. The fixed formation shoe may also be formed by several curves, for example, in such a way that the radius of the formation shoe is longer at the input end, but it becomes progressively shorter as a spiral-like arch towards the output end. In such a case the dewatering pressure is no longer constant over the formation shoe, but it remains non-pulsating nevertheless. The possibility of changing the radius in both the manners told above as well as the shoe length means that non-pulsating dewatering can always be designed to be suitable according to each application in a considerably easier way than is possible to do in connection with a roll.

The combination of a non-pulsating dewatering zone and a pulsating dewatering zone allows easier control of the dewatering between the non-pulsating and the pulsating dewatering zones, whereby the dewatering can be controlled more easily and better than in the known formers. In consequence of this, the balance between formation and retention can be better controlled and the strength properties of the web can be optimised. By adjusting the under-pressure level of the non-pulsating formation shoe it is possible to adjust the distribution of dewatering between the top and bottom surfaces of the web, which for its part affects the distribution of fines between the top and bottom surfaces. Hereby the fines content can be controlled in that surface of the pulp, which is combined with the partial web formed in the preceding wire unit. There must be sufficiently fines in the joining surfaces of the partial webs, so that a strong bond is formed between the partial webs.

The great dewatering capacity of the non-pulsating formation shoe at the beginning of the two-wire stretch makes it possible to optimise the consistency of the

web entering the two-wire stretch according to the final product to be made. In the second headbox located at the beginning of the two-wire stretch it is possible to use a consistency lower than the normal one and a lip opening bigger than the normal one. The lower input consistency improves the formation of the web to be formed. On the fixed formation shoe located at the beginning of the two-wire stretch on the side of the new pulp layer it is possible to remove enough water from the new pulp layer supplied atop the first partial web. It is hardly possible to remove any water from this new pulp layer through the first partial web already formed.

In a situation where the first wire unit is a fourdrinier wire unit, the fourdrinier wire stretch may also be shortened, because the dry-matter content of the first partial web may also be lower than usual when proceeding to the two-wire stretch of the second wire unit. The thickness of the first partial web and of the new pulp layer to be supplied atop it may also vary within a larger range than is possible at present when proceeding to the two-wire stretch of the second wire unit. In the fourdrinier wire stretch one may also use a non-pulsating formation shoe for the dewatering, whereby the high dewatering capacity of the formation shoe works in favour of a shortening of the fourdrinier wire stretch. The improved dewatering capacity allows a higher production rate.

In the fourdrinier wire unit, fines discharge from the first partial web formed on the fourdrinier wire stretch mainly through the bottom surface located against the fourdrinier wire, whereby fines will remain in the top surface of the first partial web. The second partial web is formed atop the top surface of the first partial web, where the quantity of fines is bigger. This improves the strength between the partial webs and is advantageous for joining the partial webs together.

In the following the invention will be described by referring to the figures shown in the appended drawings.

Figure 1 is a schematic side view of a formation section according to the invention provided with two wire units.

Figure 2 is a schematic side view of another formation section according to the invention provided with two wire units.

Figure 3 is a schematic side view of a third formation section according to the invention provided with two wire units.

Figure 4 is a schematic side view of a fourth formation section according to the invention provided with two wire units.

Figure 5 is a schematic side view of a fifth formation section according to the invention provided with three wire units.

Figure 6 shows an enlargement of a formation shoe used in the wire units of Figures 1-5.

Figure 1 shows a formation section provided with two successive wire units 300, 310. The first wire unit 300 is a single-wire unit and the second wire unit 310 is a two-wire unit, and the wire units 300, 310 have one wire 11 in common.

The first wire unit 300 is formed by a fourdrinier wire loop 11 and by dewatering equipment 200a, 200d arranged under the fourdrinier wire 11. A first headbox 100 supplies a pulp suspension jet on to the fourdrinier wire 11 to the forward end of the fourdrinier wire stretch, immediately after a breast roll 12 in order to form a first partial web W1. The travelling direction of fourdrinier wire 11 is indicated by an arrow S1, which thus is also the machine direction.

After the first wire unit 300 there is a second wire unit 310 having a two-wire stretch essentially in the horizontal direction. The fourdrinier wire 11 forms the

first wire of the second wire unit 310 while a separate top wire 21 forms the second wire. The top wire 21 is made to form an endless wire loop with the aid of hitch rolls and guide rolls 22a, 22b, 22c, 22d. The first roll 22a of the top wire loop 21 is fitted above the fourdrinier wire 11 in such a way that the top wire 21 and the fourdrinier wire 11 form a wedge-like jaw G2 at the forward end of the two-wire stretch of the second wire unit 310. A second headbox 110 supplies a pulp suspension jet on to the first partial web W1 into the jaw G2 of the second wire unit 310. The multi-layer web formed by the first partial web W1 and by the new pulp layer supplied on top of it is then guided in between the wires 11, 21 of the second wire unit 310. The travelling direction of the top wire 21 is indicated by an arrow S2.

At the forward end of the two-wire stretch of the second wire unit 310 two successive dewatering zones Z1b, Z2b are formed.

The first dewatering zone Z1b is formed by a first formation shoe 200b, which has a cap provided with openings and located against the inner surface of top wire 21. The first formation shoe 200b is connected to an under-pressure source (not shown in the figure), whereby an under-pressure impact is directed to the web through the openings in the cap of the formation shoe 200b. The first formation shoe 200b is further arranged in such a way that on the fourdrinier wire 11 the fibre pulp formed by the first partial web W1 arriving into the jaw G2 of the second wire unit 310 and by the new pulp layer supplied on top of it by the second headbox 110 will not hit the leading edge of the first formation shoe 200b, but after the leading edge it is guided to the area of the cap of the first formation shoe 200b. Thus, the leading edge of the first formation shoe 200b will not remove water from the fibre pulp. The first formation shoe 200b causes non-pulsating dewatering in the fibre pulp travelling in between the wires 11, 21. With the first formation shoe 200b it is possible to remove plenty of water from the new pulp layer supplied atop the first partial web W1 by the second headbox 110.

The second dewatering zone Z2b is formed by dewatering lists 210b, 230b in the cross machine direction, which are fixed and which can be loaded in a controlled manner. The fixed dewatering lists 210b are arranged inside the top wire 21 and they have gaps 220b between them, through which an under-pressure Pb can be conducted to the already partly formed web in between the top wire 21 and the fourdrinier wire 11 in order to remove water from it. Under the fourdrinier wire 11 dewatering lists 230b are arranged, which can be controlled and which are loaded against the inner surface of fourdrinier wire 11 and which are located at the gaps 220b between the fixed dewatering lists 210b. The dewatering lists 210b, 230b cause pulsating dewatering in the pulp travelling between the wires 11, 21. The formation of the web to be formed can be improved by this strongly pulsating second dewatering zone.

After the dewatering zones Z1b, Z2b there follows a transfer suction box 13, which is arranged under the fourdrinier wire 11 and which is used to make sure that the formed multi-layer web W will after the two-wire stretch of the second wire unit 310 follow the fourdrinier wire 11, from which it will later at a pick-up point (not shown) be picked up for further treatment.

In the first wire unit 300 there are also two dewatering zones Z1a, Z2a. At the first headbox 100 a second fixed formation shoe 200a is arranged under the fourdrinier wire 11. The pulp suspension jet of the first headbox 100 hits the second formation shoe 200a, preferably at an angle of 2-6 degrees, in the area immediately after the leading edge of the second formation shoe 200a. At the second headbox 110 a fourth fixed formation shoe 200d is arranged under the fourdrinier wire 11. The pulp suspension jet of the second headbox 110 hits the first partial web W1 preferably at an angle of 2-8 degrees, in the area of fourdrinier wire 11 immediately after the output edge of the fourth formation shoe 200d. These formation shoes 200a, 200d have a structure similar to that of the first formation shoe 200b located at the beginning of the two-wire stretch of the second wire unit 310. The formation shoes 200a, 200d are arranged in such a way that the pulp travelling on the

fourdrinier wire 11 will not hit the leading edge of the formation shoe 200a, 200d, but after the leading edge it is guided into the area of the cap of the formation shoe 200a, 200d. Thus, the leading edge of the formation shoe 200a, 200d does not remove water from the fibre pulp. The formation shoes 200a, 200d cause non-pulsating dewatering in the fibre pulp travelling on the fourdrinier wire 11.

Figure 2 shows another formation section provided with two successive wire units 300, 310. Both wire units 300, 310 are two-wire units and they have one wire 11 in common.

Both wire units 300, 310 are identical and they correspond to the second wire unit 310 shown in Figure 1.

In the first wire unit 300 there is a two-wire stretch essentially in a horizontal direction. The fourdrinier wire 11 constitutes the first wire of the first wire unit 300 while a separate top wire 81 constitutes the second wire. The top wire 81 is made to form an endless wire loop with the aid of hitch rolls and guide rolls 82a, 82b, 82c, 82d. The first roll 82a of the top wire loop 81 is fitted above the fourdrinier wire 11 in such a way that the top wire 81 and the fourdrinier wire 11 form a wedge-like jaw G1 at the forward end of the two-wire stretch of the first wire unit 300. A first headbox 100 supplies a pulp suspension jet on to the fourdrinier wire 11 into the jaw G1 of the first wire unit 300. The travelling direction of top wire 81 is indicated by an arrow S3.

At the forward end of the two-wire stretch of the first wire unit 300 two successive dewatering zones Z1a, Z2a are formed.

The first dewatering zone Z1a is formed by a second formation shoe 200a, which has a cap provided with openings and which is located against the inner surface of top wire 81. A second formation shoe 200a is connected to an under-pressure source (not shown in the figure), whereby an under-pressure impact is directed at

the web through the cap openings of the formation shoe 200a. The second formation shoe 200a is further arranged in such a way that the fibre pulp on the fourdrinier wire 11 arriving into the jaw G1 of the first wire unit 300 will not hit the leading edge of the second formation shoe 200a, but after the leading edge it is guided into the area of the cap of the second formation shoe 200a. Thus, the leading edge of the second formation shoe 200a does not remove water from the fibre pulp. The second formation shoe 200a causes non-pulsating dewatering in the fibre pulp travelling in between the wires 11, 81. Plenty of water can be removed from the pulp by the second formation shoe 200a.

The second dewatering zone Z2a is formed by dewatering lists 210a, 230a in the cross machine direction, which are fixed and which can be loaded in a controlled manner. The fixed dewatering lists 210a are arranged inside the top wire 81 and in between them there are gaps 220a, through which an under-pressure Pa can be conducted to the already partly formed web located in between the top wire 81 and the fourdrinier wire 11 in order to remove water from it. Under the fourdrinier wire 11 dewatering lists 230a are arranged, which can be controlled and which are loaded against the inner surface of fourdrinier wire 11 and which are located at the gaps 220a between the fixed dewatering lists 210a. The dewatering lists 210a, 230a cause pulsating dewatering in the pulp travelling between the wires 11, 81. The formation of the web to be formed can be improved by this strongly pulsating second dewatering zone.

After the dewatering zones Z1a, Z2a there follows a transfer suction box 83, which is arranged under the fourdrinier wire 11 to make sure that the formed first partial web W1 will after the two-wire stretch of the first wire unit 300 follow the fourdrinier wire 11, on which it is transferred to the second wire unit 300.

In the jaw G2 at the forward end of the two-wire stretch of the second wire unit 310 a new pulp layer is supplied on top of the first partial web W1 by a second

headbox 110. The second wire unit 310 is entirely similar to the second wire unit 310 shown in Figure 1.

Figure 3 shows a third formation section provided with two successive wire units 300, 310. Both wire units 300, 310 are two-wire units and they have one wire 11 in common. The only difference from the embodiment shown in Figure 2 is found at the forward end of the first wire unit 300. In the beginning of the two-wire stretch there are two successive formation shoes 200a1, 200a2, which are located on opposite sides of the two-wire stretch. The first formation shoe 200a1 is located inside the fourdrinier wire loop 11 and the second formation shoe 200a2 is located inside the top wire loop 81. The first headbox 100 supplies a pulp suspension jet towards the top wire 81, and the top wire 81 joins the fourdrinier wire 11 on the first formation shoe 200a1, in an area after the leading edge of the first formation shoe 200a1. Thus, the pulp will not contact the leading edge of the first formation shoe 200a1 located inside the fourdrinier wire 11, whereby the leading edge of the first formation shoe 200a1 does not remove water from the web.

Figure 4 shows a fourth formation section provided with two successive wire units 300, 310. Both wire units 300, 310 are two-wire units and they have one wire 41 in common.

The first wire unit 300 comprises a first wire 31, which is formed as a closed wire loop with the aid of hitch rolls and guide rolls 32a, 32b, 32c, and a second wire 41, which is formed as a closed wire loop with the aid of hitch rolls and guide rolls 42a, 42b, 42c, 42d, 42e. The wires 31, 41 have a common two-wire stretch directed downwards in a vertical plane, and a first jaw G1 is formed at the forward end of this two-wire stretch. A first headbox 100 supplies a pulp suspension jet into the first jaw G1 between the formation wires 31, 41, whereupon a first partial web W1 is formed on the two-wire stretch of the first wire unit 300, where there are two successive dewatering zones Z1a, Z2a. The travelling direction of the first

wire 31 is indicated by an arrow S1 and the travelling direction of the second wire 41 is indicated by an arrow S2.

At the end of the two-wire stretch of the first wire unit 300 the travelling direction of the second wire 41 is reversed with the aid of a first hitch suction roll 42b located inside the second wire loop 41. The first partial web W1 formed on the two-wire stretch is released from the first wire 31 and made to attach to the second wire 41 by the suction sector of the first hitch suction roll 42a, whereupon the first partial web W1 follows on the lower surface of the second wire 41 into the second wire unit 310.

The first wire 41 of the second wire unit 310 is formed by the second wire 41 of the first wire unit 300, which is thus formed as a closed wire loop with the aid of hitch rolls and guide rolls 42a, 42b, 42c, 42d, 42e. The second wire 61 of the second wire unit 310 is formed as a closed wire loop with the aid of hitch rolls and guide rolls 62a, 62b, 62c, 62d. The wires 41, 61 have a common two-wire stretch directed upwards in a vertical plane and a second jaw G2 is formed at the forward end of this two-wire stretch. A second headbox 110 supplies a pulp suspension jet into the second jaw G2 between the formation wires 41, 61 atop a first partial web W1, whereupon a multi-layer web W is formed on the two-wire stretch of the second wire unit 310, in which two-wire stretch there are two successive dewatering zones Z1b, Z2b. The travelling direction of the first wire 41 is indicated by an arrow S2 and the travelling direction of the second wire 61 is indicated by an arrow S4.

At the end of the two-wire stretch of the second wire unit 310, the travelling direction of the second wire 61 is reversed with the aid of a second hitch suction roll 62b located inside the second wire loop 61. The multi-layer web W formed on the two-wire stretch of the second wire unit 310 is released from the first wire 41 of the second wire unit 310 and made to attach to the second wire 61 of the second wire unit 310 by the suction sector of the second hitch suction roll 62b, where-

upon the formed multi-layer web W follows on the surface of the second wire 61 to a pick-up point P, from which the web W is transferred under the effect of under-pressure of a pick-up suction roll 72 to a pick-up fabric 71. Then the web W is transferred for further treatment on pick-up fabric 71, whose travelling direction is indicated by an arrow S5.

The dewatering arrangements of the two-wire stretch of the wire units 300, 310 are entirely similar. In each wire unit 300, 310 the dewatering arrangement is formed by two successive dewatering zones Z1a, Z2a and Z1b, Z2b.

The first dewatering zone Z1a, Z1b of wire units 300, 310 is formed by a formation shoe 200a, 200b, which is located at the beginning of the two-wire stretch and which has a cap provided with openings. The formation shoe 200a of the first wire unit 300 is located against the inner surface of the first wire 31 of the first wire unit 300. The formation shoe 200b of the second wire unit 310 is located against the inner surface of the second wire 61 of the second wire unit 310, that is, on that side of the two-wire stretch, to which a new pulp layer is supplied by the second headbox 110. The formation shoe 200a, 200b is further arranged in such a way that the fibre pulp to be supplied by the headbox 100, 110 into jaw G1, G2 will not hit the leading edge of formation shoe 200a, 200b, but it is guided after the leading edge to the area of the cap of the formation shoe 200a, 200b. Thus, the leading edge of the formation shoe 200a, 200b removes no water from the fibre pulp. By using formation shoe 200a, 200b, non-pulsating dewatering is caused in the pulp travelling in between the wires 31, 41, 41, 61.

The second dewatering zone Z2a, Z2b of wire units 300, 310 is formed by dewatering lists 210a, 230a, 210b, 230b in the cross machine direction, which are fixed and which can be loaded in a controlled manner. The fixed dewatering lists 210a, 210b are arranged on the opposite side of the two-wire stretch in relation to the formation shoe 200a, 200b and between them there are gaps 220a, 220b, through which an under-pressure Pa, Pb can be conducted to the already partly formed

web travelling in between the wires 31, 41, 41, 61 in order to remove water from it. The dewatering lists 230a, 230b, which can be loaded in a controlled manner, are located on the same side as the two-wire stretch in relation to formation shoes 200a, 200b at the gaps 220a, 220b between the fixed dewatering lists 210a, 210b. In the second dewatering zone Z2a, Z2b, pulsating dewatering is caused in the pulp travelling between the wires 31, 41, 41, 61.

Figure 5 shows a fifth formation section provided with three successive wire units 300, 310, 320. Two successive wire units 300, 310 and 310, 320 always have one wire 41 and 51 in common. Thus, to the embodiment shown in Figure 5 one wire unit has been added compared with the embodiment shown in Figure 4.

The first wire unit 300 shown in Figure 5 is similar to the first wire unit 300 shown in Figure 4, with the difference that the two-wire stretch is here directed upwards in a vertical plane. The third wire unit 320 shown in Figure 5 for its part is similar to the second wire unit 310 shown in Figure 4. The second wire unit 310 shown in Figure 5 is similar to the first wire unit 300, but the two-wire stretch is directed downwards in a vertical plane. The first dewatering zone Z1a of the first wire unit 300 is formed by a fixed formation shoe 200a, which places itself against the inner surface of the first wire 31 of the first wire unit 300. The first dewatering zone Z1b, Z1c of the two-wire stretch of the second 310 and third 320 wire units is formed by a fixed formation shoe 200b, 200c, which places itself on that side of the two-wire stretch, to which the new pulp layer is supplied by the headbox 110, 120. The second dewatering zone Z2a, Z2b, Z2c is formed by fixed dewatering lists 210a, 210b, 210c, which are mounted on the opposite side of the two-wire stretch in relation to the formation shoe 200a, 200b, 200c, and by gaps 220a, 220b, 220c between them, through which an under-pressure Pa, Pb, Pc can be conducted to the already partly formed web travelling between the wires 31, 41, 41, 51, 51, 61 in order to remove water from it. The dewatering lists 230a, 230b, 230c, which can be loaded in a controlled manner, are located on the opposite side of the two-wire stretch in relation to the fixed dewatering lists 210a,

210b, 210c at the gaps 220a, 220b, 220c between the fixed dewatering lists 210a, 210b, 210c.

Figure 6 shows an enlargement of the fixed non-pulsating formation shoe 200a, 200b, 200c, 200d, 200a1, 200a2 shown above in Figures 1-5. The formation shoe has a curved cap 201, which is placed against the inner surface of the formation wire 11, 31, 51, 61 and which has a leading edge 203 and a trailing edge 204. The cap 201 has an open surface formed by openings 202 extending through the cap 201. Openings 202 may be formed by holes, grooves, gaps or equivalent. Under the cap 201 an under-pressure is arranged, which is marked by the reference mark P and illustrated by an arrow and which is used to remove water from the pulp located on the wire 11 or in between the wires 11, 21, 31, 41, 41, 61, 41, 51, 51, 61. The openings 202 are arranged in such a way in the cap 201 of the formation shoe that the open surface area of said cap 201 is large, most preferably 50-90 %, and so that they do not due to their design and/or arrangement cause any pressure pulses in the web. Pressure pulses may be caused in the web, if the formation wire 11, 21, 31, 51, 61 travelling on cap 201 is not evenly supported over the whole area of cap 201. Pressure pulses will not be caused, if the openings are formed by holes or by gaps essentially in the lengthwise direction of the machine. When the openings 202 are formed by holes, they are preferably arranged against the travelling direction S of the wire 11, 21, 31, 51, 61 travelling over cap 201 obliquely in relation to cap 201 in such a way that the water is better guided into them. The angle α between the central axis of holes 202 and a tangent to the cap's 201 outer surface is within a range of 30-60 degrees. Cap 201 is formed as a curved cap in such a way that the cap's 201 radius of curvature R is within a range of 1-20 m. The radii of curvature R of the cap 201 of formation shoes located in the two-wire stretch are within a range of 1-5 m and the radii of curvature R of the cap 201 of formation shoes located in the single-wire section are within a range of 5-20 m. The overlap angle of wire 11, 21, 31, 51, 61 in the area of cap 201 is within a range of 3-45 degrees, preferably 5-30 degrees. The cap length A in the machine direction is within a range of 200-1000 mm. Cap 201 may also be formed by sev-

eral parts having different radii of curvature R. The level of under-pressure to be used in the formation shoe is preferably within a range of 1-30 kPa.

By changing the radius of curvature R of the cap 201 of the formation shoe and/or by changing the under-pressure P existing in the shoe and/or the shoe length A it is possible to control the quantity and distribution of the water removed by the formation shoe from the web.

When a non-pulsating formation shoe 200a, 200d is used for dewatering in the fourdrinier wire unit 300, the fines in the first partial web W1 discharge mainly from the surface of the first partial web W1 located against the fourdrinier wire 11, whereby fines will remain in the top surface of the first partial web W1. From the viewpoint of joining together the first partial web W1 and the fibre layer to be supplied on top of it, it is an advantage to have fines in the top surface of the first partial web W1.

In the embodiments shown in Figures 1-3 one or more successive wire units may be placed behind the second wire unit 310, depending on the number of layers desired in the final web. At the beginning of each two-wire unit following after the first wire unit 300 a new layer is always formed by the headbox atop the preceding layers.

In the embodiments shown in Figures 4-5, it is of course also possible when required to use several successive two-wire units depending on the number of layers desired in the web.

In the embodiments shown in Figures 4-5, the fixed dewatering lists 210a, 210b, 210c may also be on the same side of the two-wire stretch as the formation shoes 200a, 200b, 200c.

In the embodiments shown in the figures only one formation shoe is shown at the beginning of the two-wire stretch of the second wire unit, but there may also be more formation shoes. At the beginning of the two-wire stretch there may be, for example, two formation shoes mounted on opposite sides of the two-wire stretch, as is the case in the first wire unit of the formation section shown in Figure 3. A meandering path is hereby formed on the wires, which may cause runnability problems. On the same side of the two-wire stretch there may also be several successive formation shoes, if, for example, different under-pressure levels are desired in the different formation shoes.

The headboxes 100, 110, 120 shown in the figures may be single-layer headboxes or multi-layer headboxes.

The consistency of the pulp suspension supplied by the first headbox 100 is within a range of 0.5-1.5 % and the consistency of the pulp suspension supplied by the second headbox 110 and by the following headboxes 120 is within a range of 1.0-2.0 %.

In the embodiment shown in Figure 1, approximately 60-80 % of the quantity of water contained in the pulp suspension supplied by the first headbox 100 are removed in the first wire section 300 and approximately 5-15 % are removed in the second wire section 310. Of the quantity of water contained in the pulp suspension supplied by the second headbox 110 about 20-50 % are removed in the first non-pulsating dewatering zone Z1b and about 15-30 % are removed in the second pulsating dewatering zone Z2b.

In the embodiments shown in the figures the second dewatering zone Z2b of the second wire unit 310 is formed by fixed dewatering lists 210b and by dewatering lists 230b, which can be loaded in a controlled manner. The second dewatering zone Z2b may also be formed only by fixed dewatering lists 210b. The fixed dewatering lists 210b may form a direct passage for the wires travelling over them.

With the under-pressure existing in the gaps 220b between the fixed dewatering lists 210b the passage of wires is somewhat deviated in said gaps 220b, whereby pulsating dewatering is brought about in the web located between the formation wires. The fixed dewatering lists 210b may also be located in such a way that they form a curved passage for the wires travelling over them. Hereby the dewatering lists 210b are at a small angle of about 0.5-2 degrees in relation to one another. By such an arrangement a boosted pulsating dewatering is brought about in the web located between the formation wires travelling over the dewatering lists. In both cases, the pulsating effect is boosted even more by using both fixed dewatering lists 210b and dewatering lists 230b, which can be loaded in a controlled manner.

Only some advantageous embodiments of the invention have been presented in the foregoing, and it is obvious to a professional in the art that numerous modifications can be made to them within the scope of the appended claims.